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AUTHOR Flake, Janice L.
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ABSTRACT

With the use of classroom simulations, theory and field research can be synthesized, thus bringing both thecry and research into an "action" form for the education student. Interactive computer systems allow for active involvement and immediate feedback. One classroom simulation, already constructed, is described. Fcr this simulation a conceptualization of classrocm discourse was used for the design, with the participant choosing an objective for the lesson to be "taught," selecting a teaching strategy, and hence desigrating individual moves. Also described are the development of the prcgram, simulation evaluation, and suggested further work in simulaticns. (JA)

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Abstract: Educational theory can be made more concrete for education students through the use of technology. Classroom simulations can be constructed so that students "instruct" simulated pupils. Such simulations can synthesize theory and field research, thus bringing both theory and research into an "action" form for the student. Interactive computer systems allow for active involvement and immediate feedback. One classroom simulation, already constructed, and other suggested simulations are described.

Title: Interactive Computer Simulations - A New Component to Teacher Education

Author: Janice L. Flake
Mathematics Department
Eastern Illinois University
Charleston, Illinois

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Teaching is a complex process, with many phenomena occurring simultaneously. The naïve teacher is often totally oblivious to much of what is happening and/or fails to make maximum use of his abilities to bring about desired outcomes.

In the Gregorc (1971) model, four levels of teacher awareness have been identified. These four levels can be referred to as: (1) imitating others, (2) using hunches, (3) identifying principles, and (4) applying these principles. Identifying and applying principles form the process of building a theoretical background from which one can operate. The responsibility of teacher educators would seem to be to help teachers move to higher awareness levels. Thus the teacher educator should consider educational theory and effective methods of demonstrating the implementation of that theory.

Many teacher education programs are structured to give students lectures concerning educational theories with little or no immediate application of these theories. Often the first real opportunity for the teacher education student to apply these theories is during his student teaching. Student teaching, however, frequently occurs several terms after the theory courses, by which time the student, frequently forgetting the theories, is overwhelmed by the complexities of student teaching.

Broudy (1964) outlines the various stages he sees in

the professional preparation of teachers. These stages include: laboratory experience, clinical experience, and internship. Broudy says,

> Internship is not the time or place to learn theory or technique; it is the time for applying them; for achieving facility and confidence rather than a time for experimentation or playing with ideas for the joy of doing so (p. 14).

How can theory be made more relevant? One way is through appropriate laboratory experiences. Laboratory experiences may help the participant believe the text. A more sophisticated use of the laboratory experience is for discovery or for answering the student's questions; he has to experiment using the interaction of several previously learned principles to test an hypothesis. The laboratory is a place designed for observation, experimentation, and manipulation. The participant can ask, "What will happen if I do . . .?"

What types of laboratory activities exist for education students? One type of laboratory experience is the use of simulation activities. Simulation is a working analogy. The analogy may be of some form of reality, e.g., the analogy of flying an airplane as in the "Link Flight" trainers, or of teaching a class. The idea is to put the participant in the middle of a simulated problem situation; through manipulating the situation, he is to solve the problem.

A simulation study involves the underlying structure of a model. A model for a simulation may be a systems approach. A system is a group of interdependent elements acting together to accomplish a pre-determined purpose. For example, several educational theories, e.g., teaching strategies and questioning behaviors, can be written into the model.

What about the use of interactive computer simulations in teacher education? Simulations can have a rather dynamic place in a teacher education program. The participant can "teach" simulated classes so that he has to "live with" the situation he has created, i.e., experience and cope with the consequences of his choices and decisions. This situation changes step for step.

An important aspect of the use of an interactive computer is the immediate feedback that one can get. Feedback can be used to give a participant information as he uses the program through the interaction process, as well as a reflective analysis of his use of the program. A participant can gain deeper insights into educational theories through the use of the program. Empirical support of the view that immediate knowledge of results contributes to rapid learning has been given by research conducted by Angell (1949), DeCecco (1968), Schramm (1962), and Weiner (1954).

An example of an interactive computer simulation for teacher education was written by Flake (1973) using the

PLATO (Programmed Logic for Automatic Teaching Operation) system at the University of Illinois at Urbana-Champaign. The program focused upon teaching strategies and questioning behaviors. Pre-service mathematics methods students were used as participants. The participant "taught" a simulated class via an interactive PLATO computer terminal. He would "ask" a question of the class, get a response from one of the simulated students, "ask" another question, get a response, etc. Through his questions he was to "teach" the simulated students a principle.

Constructing a Simulation

The construction of simulations, exhibiting behaviors in teaching, should be viewed as long-range projects. To start the development of the actual computer program much background is needed. Conceptualization of the development is represented in Figure 1.

Insert Figure 1 here.

Educational research has had emphasis placed upon the collection of empirical data. Empirical data, collected for the purpose of developing theories, should be such that models can be abstracted. Types of field research considered are: (1) What types of behaviors exist? and (2) What combinations of such behaviors yield what sorts of results?

Examples of research, identifying types of behaviors, are found in Henderson (1963), (1967), (1969), and (1971), Semilla (1971), and Todd (1972). In these cases audio-

tapes of classes taught by purportedly good mathematics teachers were collected. These tapes were carefully analyzed to identify: (1) types of content taught, e.g., concepts (meanings of terms), principles (generalizations), and skills, and (2) kinds of moves, e.g., instance, assertion, and teaching strategies (sequences of moves), e.g., instance, instance, ... , assertion, used to teach such content.

An example of research, examining combinations of behaviors yielding certain results, was conducted by Sowder (1970). Sowder studied the number of instances needed by junior high school students to discover the pattern for "The sum of the first n odd positive integers." His study revealed that students needed between 3 and 8 instances to gain insight into the pattern; he also found that brighter students needed fewer instances than less bright students.

Another example of research was the study of the relationship between the wait-time from the time a question was asked until it was answered. Research by Rowe (1972) indicated that the length of this time affects the quality of the answer; wait-times of at least 5 seconds yield responses reflecting more thought.

Considerable research concerning various questioning behaviors has been done. For additional details see Flake (1973).

Design of the Program

In order to design a computer program for simulation,

a conceptualization of that to be simulated must first be decided upon. Such a scheme should reflect the results of the best theories of teaching and learning possible. Whenever possible, the design should reflect the results of field research.

For the program under consideration, a conceptualization of classroom discourse was used for the design. The scheme consisted of the participant choosing an objective for the lesson to be "taught," selecting a teaching strategy, and hence designating individual moves. This incorporated a version of the Henderson moves and strategies. In the conception, the teacher exerted a move, exhibited various questioning behaviors (incorporating research on questioning), got a simulated student response, reacted to that response, made another move, etc. This scheme was the foundation for designing the program.

The program incorporated findings from research, decisions throughout classroom discourse to be made by the participant, the simulated students' performance, and types of feedback given to the participant. Included in the program were various programming techniques, such as the uses of counters, branching decisions, storage of data, which made the entire simulation possible.

What decisions were to be made by the participant? Such decisions while using the program are shown in Figure 2.

Insert Figure 2 here.

First the participant was to decide upon the objective of the lesson. For example he was to decide whether the purpose of the lesson was: (1) to know the specific principle itself, (2) to apply the principle to a new situation, or (3) to develop problem-solving strategies. Selection of the objective of the lesson was to suggest a teaching strategy. One strategy that could be used is:

(1) Assertion, e.g., "The sum of the first n odd positive integers is n^2."

(2) Instance, e.g., "What is the sum of the first 3 odd positive integers?"

(3) Instance, e.g., "What is the sum of the first 4 odd positive integers?"

etc.

This is a deductive strategy which could be used to teach the student to know the principle. If the purpose of the lesson was to develop problem-solving strategies, a deductive strategy of the above form would not encourage students to look for relationships.

Students can be taught the principle: Given a difficult problem, look for simpler related problems (Wills, 1967). Thus for the problem-solving objective, participants were encouraged to follow a strategy, such as:

(1) Ask a difficult to answer question, e.g., "What is the sum of the first 200 odd positive integers?" (This assumes that the students do not know the principle.)

(2) Ask a focus question, e.g., "How would one start to find the solution to this problem?", "What is a simpler related problem?"

(3) Eventually come to a simple instance.

After selecting a strategy, the participant chose individual moves within the strategy. Such a move consisted of giving an assertion of the principle, asking for the assertion ot the principle, etc. The move might have been to ask a question. If the participant did not ask a question, he went to the next move. If he asked a question, he then decided whether to solicit volunteers, how long to wait (wait-time) before calling upon a student, and how to distribute the questions among the class members. After making these decisions, the participant was given a simulated student response. Then the participant decided how to react to that response; he could praise, reject, ask for student opinion, probe deeper, or ignore the response.

Continuing to make his moves, get student responses, react to student responses, etc., the participant eventually decided he had achieved his objective, hence terminating the lesson. He then received feedback evaluating the lesson and his questioning behaviors.

How were simulated students programmed to perform? Performances were determined by performance-level (PL) numbers assigned to the students. The numbers ranged from 0 to 20. Students with higher performance-level numbers were programmed to "perform" better in the sense that they

"remember" subordinate information (i.e., information needed to teach the lesson at hand) better and "learn" the principle with fewer instances. Simulated students with PL's higher than 15 were programmed to "remember" subordinate information; others were not. For example, if one were to ask "What is the sum of the first 3 odd positive integers?", the student must "understand" the concept of an odd positive integer. If this concept had not been taught, then simulated students with PL's less than 15 would ask, "What is an odd positive integer?" Hence, the participant was to realize that he needed to teach this concept.

How were the simulated students programmed to "learn" the principle? To program the students to "catch on" to the principle, results of Sowder's study were incorporated. Simulated students, with PL's larger than 15, were programmed to "catch on" after three correct instances; students, with $5 \leq PL \leq 15$, "caught on" with an inverse proportional number of instances, e.g., PL = 12 required 4 correct instances, PL = 8 required 6 correct instances; students, with PL's below 5, did not "catch on" but did understand the principle after "hearing" the assertion of the principle, followed by a couple of correct instances.

How was the participant to learn from the program? Feedback was given to the participant in several forms. Throughout the program the participant was given feedback in the form of simulated student responses, e.g., responses

indicative of whether students were "learning" the principle. At the end of the lesson, the participant was given additional feedback in the forms of: (1) simulated students' performance on a mini-test relating the selected objective and teaching strategies employed, and (2) information about the participant's questioning behaviors. Participants were encouraged, through feedback to go beyond first responses by redirecting and probing. The type of immediacy of feedback shaped the focus given by the participant to the program.

Development of the Program

To enhance the reality of the program, experienced mathematics teachers, as well as methods students were asked to "teach" the simulated class during early stages of development. Their comments were carefully noted, and needed changes were made. The evolution of the program was an ever changing process.

Using a Simulation

As mentioned in Broudy's (1964) article, the laboratory is to bring relevance between theory and practice. Simulations may be used to supplement class discussions. Theories may be discussed in class, after which students can go to the laboratory (in this case consisting of interactive computer terminals) and attempt to implement the theories with a simulated class. After the laboratory activities, students can return to class, discuss their results, compare strategies, return to the laboratory, etc.

The program under discussion has been used in a variety of ways with a total of four methods classes of approximately 100 students. (Three classes were used for developmental purposes; the fourth class was used for experimental purposes to evaluate the effect of the program.) The program can be used for at least five one-hour sessions. At first participants learned sequencing of questions in logical order, after which they tended to focus upon various questioning behaviors, as well. About an equivalent amount of time was spent off the machine, in discussion.

Evaluating a Simulation

According to the Gregorc (1971) model, emphasis was placed on awareness levels of educational theories. An effective simulation should lead the participant to an increased awareness of such theories.

This particular simulation did show that the participants' awareness levels increased in the experimental class, a total of 25 students, for which measures were taken. Twenty-two out of 25 demonstrated an increase of behavior of going beyond first responses of a student response; nineteen out of 25 increased their behavior of modeling the prescribed problem-solving strategy. Most of the participants (24 out of 25) demonstrated a positive attitude towards the over-all unit. The majority of the students (23 out of 25) felt that they learned much by working with the program.

Sample comments made by students using this program are:

"It made me realize the importance of subtasks. It can be very disastrous to assume a class knows certain definitions and principles. One must make sure that they understand what is happening."

"Truly interesting and educational. Really got me excited about working with real 'victims.'"

"It made me think about the type of problems I would run into when trying to teach what seemed to me a simple principle."

"It was neat to get the individual experience of being on my own and planning my own strategy. Got much more understanding of strategy and all."

"I thought it was very worthwhile and valuable - and quite an enjoyable experience! Both computer sessions and class discussions have given me a greater insight into the role of the teacher and what will be expected of me."

"This was a worthwhile experiment for it gives us a chance to make mistakes and be evaluated immediately. This way we're not hurting any students' learning process because they were not real."

"No amount of talking, reading, or observation could have given me as much insight into planning, teaching

strategy, reacting to student responses, etc."

Suggested Further Work in Simulations

A computer-assisted instruction component of a teacher education program need not restrict itself to teaching strategies and questioning behaviors. There are a number of aspects that one might consider for the use of such a component. Some such aspects might be:

1. Diagnosis of errors - remediation

   A student makes an error. The participant has to identify the error, infer the cause of the error, find ways of getting the student to see the error, and find procedures for correcting the error.

2. Discipline and classroom management

   A discipline problem occurs. The participant takes an action. The student reacts in a certain way. The participant then reacts, ... For example, a student gets noisy. The participant reacts by saying, "Get quiet or leave!" The student says, "Make me!" The participant ...

3. The effects of differentiated feedback on retention and transfer

   The participant gives the student different types of feedback and gets different results.

4. Interaction analysis

   Simulations could be constructed such that one can gain a greater insight as to how to use classroom time.

5. Curriculum planning

   This might be a simulation of a department meeting or a curriculum committee meeting, in which a curriculum is being planned. One would need to consider what content should be included and how it should be sequenced. Such ideas as Gagné's learning hierarchies should emerge.

These are only a few examples of what might be simulated for the use of a computer-assisted instruction component in a teacher education program. In each of the above areas, empirical data need to be collected from the field so that models can be abstracted. Once the models are abstracted, instances of those models could be used to sensitize teacher education students as to various types of behaviors that they can (and perhaps should) exhibit.

The use of technology has begun to be explored in the area of teacher education, but it has not been completed. The use of technology shows much promise as a means for making theory more concrete, as well as synthesizing much field research into an "action" form for the teacher education student.

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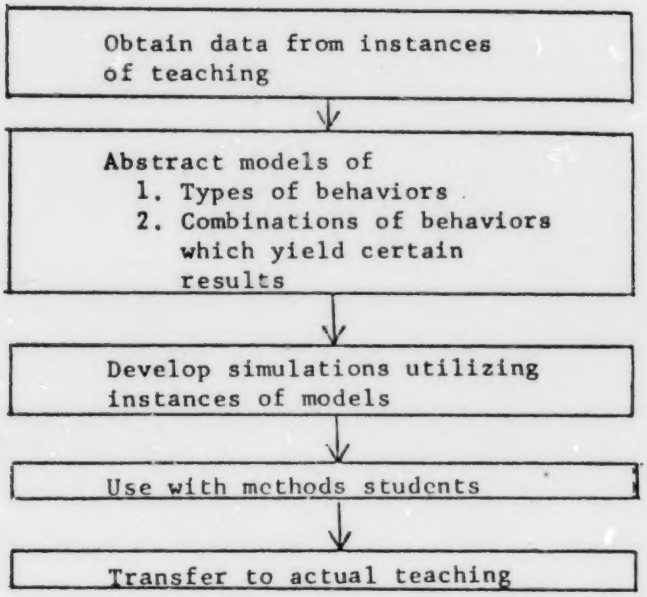
Obtain data from instances of teaching
Abstract models of
1. Types of behaviors
2. Combinations of behaviors which yield certain results
Develop simulations utilizing instances of models
Use with methods students
Transfer to actual teaching

Figure 1. Conceptualization of the Construction of a Simulation

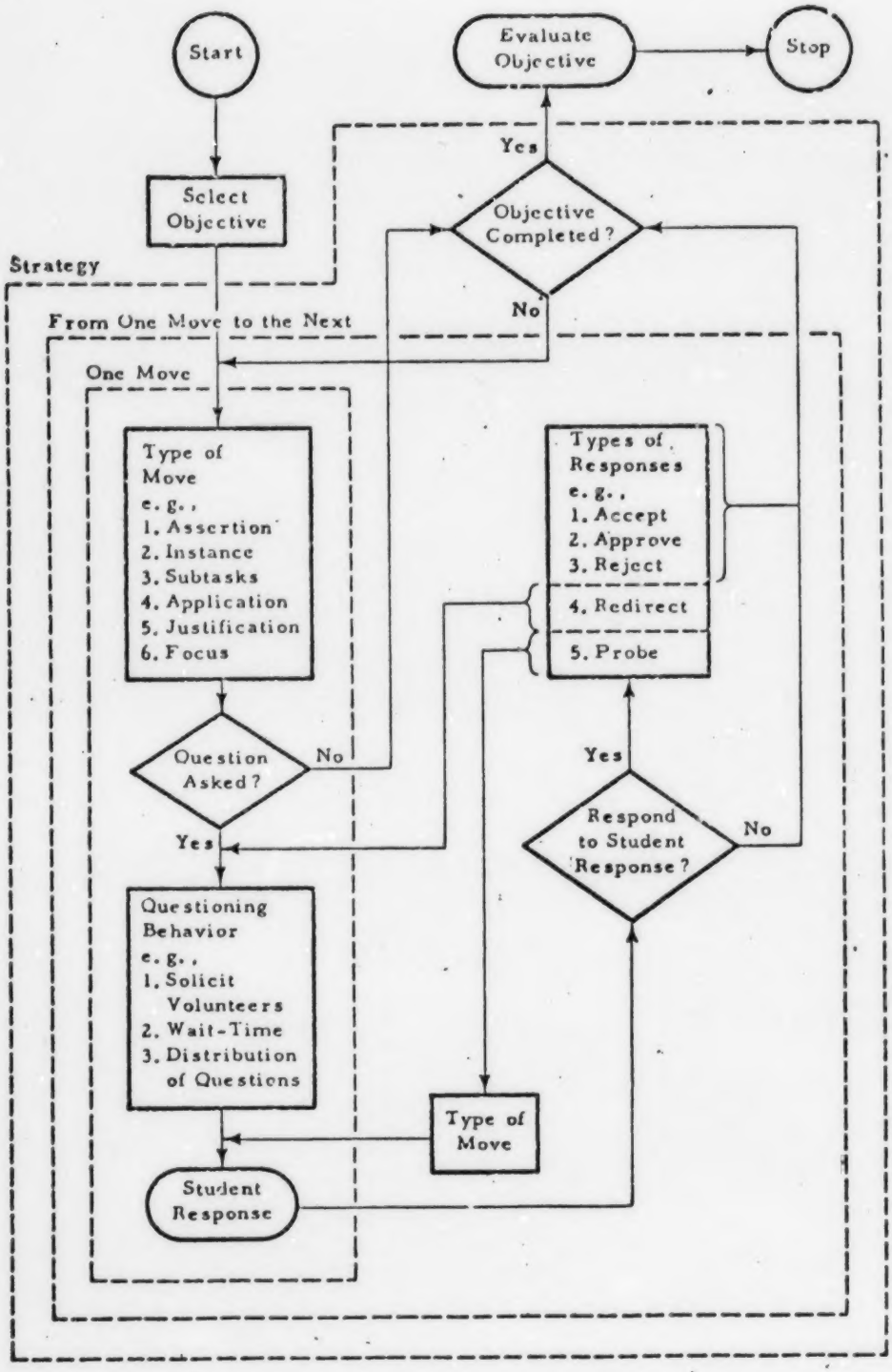

Figure 2. Decisions a Teacher Makes in Classroom Discourse

indicative of whether students were "learning" the principle. At the end of the lesson, the participant was given additional feedback in the forms of: (1) simulated students' performance on a mini-test relating the selected objective and teaching strategies employed, and (2) information about the participant's questioning behaviors. Participants were encouraged, through feedback to go beyond first responses by redirecting and probing. The type of immediacy of feedback shaped the focus given by the participant to the program.

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